

We claim:

1           1.       A perpendicular recording write head, comprising:  
2               a first and second ferromagnetic pole piece, the second pole piece with a front end  
3       recessed from the ABS and magnetically connected to a back gap magnetically coupling  
4       the first and second pole pieces;  
5               a coil structure between the first and second ferromagnetic pole piece;  
6               a write pole sub layer, formed over the second pole piece, the write pole sub layer  
7       having a taper at a pole tip region toward the air bearing surface (ABS);  
8               a magnetic material disposed on top of the write pole sub layer;  
9               a laminated write pole layer, formed over the write pole sub layer, the laminated  
10      write pole layer formed of high magnetic saturation material with interspersed non-  
11      magnetic film magnetically coupled with the write pole sub layer;  
12              a laminated write pole shaped from the laminated write pole layer;  
13              a non-magnetic material encapsulating the write pole;  
14              a ferromagnetic write shield layer disposed over the non-magnetic material  
15      encapsulating the write pole; and  
16              at least one ferromagnetic stud magnetically connecting the first pole piece and  
17      the write shield layer.

1           2.       The perpendicular recording write head of claim 1, wherein the write pole  
2       further comprises a trapezoidal shape to prevent adjacent track writing when skew is  
3       experienced while flying over the disk.

1           3.       The perpendicular recording write head of claim 1, wherein the laminated  
2 write pole includes a tapered portion.

1           4.       The perpendicular recording write head of claim 1, wherein the  
2 encapsulating non-magnetic material further comprises a reactive ion etchable (RIEable)  
3 material.

1           5.       The perpendicular recording write head of claim 4, wherein the RIEable  
2 material is selected from a group of materials comprising TaO<sub>x</sub>, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, Ta, W,  
3 Al<sub>2</sub>O<sub>3</sub>.

1           6.       The perpendicular recording write head of claim 1, further comprising a  
2 write gap layer of non-magnetic materials formed on the top of the write pole layer.

1           7.       The perpendicular recording write head of claim 1, further comprising an  
2 overcoat deposited over the fourth stud segments and the trailing shield.

1           8.       The perpendicular recording write head of claim 1, wherein the pole tip is  
2 laterally surrounded by a non-magnetic material.

1           9.     A magnetic head assembly that has a head surface, a read head and a  
2 perpendicular recording write head, comprising:  
3           the read head including:  
4                 ferromagnetic first and second shield layers; and  
5                 a read sensor located between the first and second shield layers; and  
6           the perpendicular recording write head including:  
7                 a first and second ferromagnetic pole piece, the second pole piece with a  
8 front end recessed from the ABS and magnetically connected to a back gap magnetically  
9 coupling the first and second pole pieces;  
10                a coil structure between the first and second ferromagnetic pole piece;  
11                a write pole sub layer, formed over the second pole piece, the write pole  
12 sub layer having a taper at a pole tip region toward the air bearing surface (ABS);  
13                a magnetic material disposed on top of the write pole sub layer;  
14                a laminated write pole layer, formed over the write pole sub layer, the  
15 laminated write pole layer formed of high magnetic saturation material with interspersed  
16 non-magnetic film magnetically coupled with the write pole sub layer;  
17                a laminated write pole shaped from the laminated write pole layer;  
18                a non-magnetic material encapsulating the write pole;  
19                a ferromagnetic write shield layer disposed over the non-magnetic  
20 material encapsulating the write pole; and  
21                at least one ferromagnetic stud magnetically connecting the first pole piece  
22 and the write shield layer.

1           10.     The magnetic head assembly of claim 9, wherein the write pole further  
2 comprises a trapezoidal shape to prevent adjacent track writing when skew is experienced  
3 while flying over the disk.

1           11.     The magnetic head assembly of claim 9, wherein the laminated write pole  
2 includes a tapered portion.

1           12.     The magnetic head assembly of claim 9, wherein the encapsulating non-  
2 magnetic material further comprises a RIEable material.

1           13.     The magnetic head assembly of claim 12, wherein the RIEable material is  
2 selected from a group of materials comprising TaO<sub>x</sub>, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, Ta, W, Al<sub>2</sub>O<sub>3</sub>.

1           14.     The magnetic head assembly of claim 9, further comprising a write gap  
2 layer of non-magnetic materials formed on the top of the write pole layer.

1           15.     The magnetic head assembly of claim 9, further comprising an overcoat  
2 deposited over the fourth stud segments and the trailing shield.

1           16.     The magnetic head assembly of claim 9, wherein the pole tip is laterally  
2 surrounded by a non-magnetic material.

1           17.     A method of making a perpendicular recording write head, which has a  
2     head surface comprising:  
3           forming a first and second ferromagnetic pole piece, the second pole piece with a  
4     front end recessed from the ABS and magnetically connected to a back gap magnetically  
5     coupling the first and second pole pieces;  
6           forming a coil structure between the first and second ferromagnetic pole piece;  
7           forming, over the second pole piece, a write pole sub layer having a taper at a pole  
8     tip region toward the air bearing surface (ABS);  
9           forming a magnetic material on top of the write pole sub layer;  
10          forming, over the write pole sub layer, a laminated write pole layer of high  
11     magnetic saturation material with interspersed non-magnetic film magnetically coupled  
12     with the write pole sub layer;  
13          shaping a laminated write pole from the laminated write pole layer using reactive  
14     ion etching;  
15          encapsulating the write pole in a non-magnetic material;  
16          forming a ferromagnetic write shield layer over the non-magnetic material  
17     encapsulating the write pole; and  
18          forming at least one ferromagnetic stud magnetically connecting the first pole  
19     piece and the write shield layer.

1           18.     The method of claim 17, wherein the shaping further comprises forming,  
2     of a CMP stop layer and an ion mill mask, a hard mask layer having a shape of a desired  
3     write pole on top of the laminated write pole layer and reactive ion etching laminated  
4     write pole layer to form the write pole.

1           19.     The method of claim 17, wherein the defining the write pole further  
2     comprises shaping the write pole with a trapezoidal shape to prevent adjacent track  
3     writing when skew is experienced while flying over the disk.

1           20.     The method of claim 17, wherein the laminated write pole includes a  
2     tapered portion.

1           21.     The method of claim 17, wherein the depositing the magnetic material on  
2     top of the write pole sub layer further comprises patterning a non-magnetic sacrificial  
3     layer to form a write pole sub layer having a taper at a pole tip region toward the air  
4     bearing surface and planarizing the magnetic material to expose the top surface of write  
5     pole sub layer.

1           22.     The method of claim 21, wherein the planarizing the magnetic material  
2     comprises chemical mechanical polishing (CMP).

1           23.     The method of claim 21, wherein the patterning the non-magnetic  
2     sacrificial layer is formed by ion mill or reactive ion etching.

1           24.     The method of claim 17, wherein the encapsulating the write pole in a  
2 non-magnetic material further comprises using a RIEable material.

1           25.     The method of claim 24, wherein the RIEable material is selected from a  
2 group of materials comprising TaO<sub>x</sub>, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, Ta, W, Al<sub>2</sub>O<sub>3</sub>.

1           26.     The method of claim 17, further comprising depositing a CMP stop layer  
2 after depositing the encapsulating non-magnetic layer for better CMP control.

1           27.     The method of claim 17, further comprising depositing a write gap layer  
2 of non-magnetic materials on the top of the write pole layer.

1           28.     The method of claim 17, wherein the forming the trailing shield further  
2 comprises forming a trailing shield photoresist, forming the trailing shield and lifting the  
3 resist off.

1           29.     The method of claim 17, wherein the forming the trailing shield further  
2 comprises depositing a seed-layer on top of a write gap, plating the trailing shield and  
3 removing exposed seed-layer.

1           30.     The method of claim 17, further comprising depositing an overcoat over  
2 the fourth stud segments and the trailing shield.

1           31.     The method of claim 17, wherein the pole tip is laterally surrounded by a  
2 non-magnetic material.